PATENT

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APPLICATION

OF

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FOR

METHOD FOR GENERATING A SCREENED REPRESENTATION OF AN IMAGE

METHOD FOR GENERATING A SCREENED REPRESENTATION OF AN IMAGE

The application claims the benefit of US Provisional Application No. 60/432,282 filed on December 9, 2002.

FIELD OF THE INVENTION

The present invention relates to the halftoning of continuous tone images for use in reproduction of such images.

BACKGROUND OF THE INVENTION

Many reproduction devices are not capable of reproducing a continuous range of tones. For example, offset printing or inkjet printing methods can either deposit ink or not. Several techniques have been developed to simulate continuous tones on such devices. These simulated continuous tones are called halftones. The process that is used to obtain halftones is called screening. Screening breaks an image down into a series of dots. Varying the dot sizes, the number of dots, or both, approximates shades of color. The eye is not able to see the individual halftone dots, and only sees the corresponding "spatially integrated" density value. In a black-and-white printed image, for example, a group of large dots placed closely together appears black. A group of smaller dots with larger spaces between them produces a weaker, gray shade. A group of even smaller dots spaced widely apart appears almost white.

In traditional graphic arts, screening was generally done using a screen-like pattern etched into a glass plate. A camera operator had several of these plates, each with a different pattern. The image to be reproduced was projected through a chosen screen onto film, and the resulting image looked like the original except that it was broken down into a lot of little dots.

Imagesetters (and platesetters) create an electronic version of the traditional halftone screen. Screening software in the imagesetter applies an electronic dot pattern to the electronic

image. In electronic screening, the halftone dots are made up of several microdots; a microdot is the smallest unit that can be addressed by the imagesetter.

Two major classes of screening methods are known: AM screening (Amplitude Modulated screening) and FM screening (Frequency Modulated screening). In AM screening, the halftone dots, that together will give the impression of a particular tone, are arranged on a fixed geometric grid. By varying the size of the halftone dots, the different tones of images can be simulated. AM screening is also called dot-size modulation screening or dot-clustered screening. In FM screening, the distance between the halftone dots is modulated rather then their size. FM screening is also called stochastic screening or dot-dispersed screening. Agfa's CristalRaster™ is an example of FM screening, while Agfa Balanced Screening™ (ABS) is an AM screening technology. More information on AM and FM screening can be found in EP-639023-B1 herein incorporated by reference in its entirety for background information.

Many FM screening methods reproduce the midtones of an image with poorer quality, due to effects such as graininess and uncontrolled dot clustering. There is thus a need for an improved screening method.

SUMMARY OF THE INVENTION

The present invention is a method for generating a screened representation of an image as claimed in independent claims 1 and 9. Preferred embodiments of the invention are set out in the dependent claims. Preferably, a method in accordance with the invention is implemented by a computer program product as claimed in claims 20 and 23. The invention also includes a printing plate as claimed in claim 18.

A screening method in accordance with the invention is partially FM and partially AM. In a preferred embodiment, FM screening is applied to the highlights and the shadows, while AM

screening is applied to the midtones. For the highlights, FM dots
are generated. In the midtones, these FM dots are enlarged by
adding one or more microdots to them, i.e. the dots "grow" - which
is AM screening. In the shadows, remaining "holes" between the dots
5   are removed - which is FM screening again.

     An advantage of a method in accordance with the invention is
that clustering of dots in the midtones is more controllable,
resulting in a higher perceived quality of the printed image in the
midtones. Another advantage is that, depending on the design of the
10   writing heads of some imagers, some severe banding is avoided.

     Further advantages and embodiments of the present invention
will become apparent from the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

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     The invention is described with reference to the following
drawings without the intention to limit the invention thereto, and
in which:

     Figs. 1A to 1F show an embodiment in accordance with the
20   invention;

     Fig. 2 shows a detail of another embodiment in accordance with
the invention;

     Fig. 3 shows how density varies for yet another embodiment in
accordance with the invention;

25   Fig. 4 shows how density varies for the embodiment illustrated
by Figs. 1A to 1F;

     Fig. 5 shows still another embodiment in accordance with the
invention; and

     Fig. 6 shows a prior art embodiment.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

     A preferred embodiment of the invention is illustrated by
Figs. 1A - 1F. These drawings show dot patterns for six increasing
35   densities, from highlights (Fig. 1A) to shadows (Fig. 1F). Fig. 1A

shows a number of first dots 11, arranged in a frequency modulated

pattern. This frequency modulated pattern may be obtained by means

of a randomized Bayer matrix, as disclosed in EP-642259-B1, herein

incorporated by reference in its entirety for background

5   information, and as used in Agfa's CristalRaster™. The first dots

11 all have a first dot size. With increasing density, more first

dots 11, having this first dot size, may be added to those shown in

Fig. 1A. With still further increasing density, as shown in

Fig. 1B, a number of second dots 12, selected out of the first dots

10   11, are enlarged by adding one or more microdots 13 to these second

dots 12. The number of second dots 12 is at most equal to, i.e. is

smaller than or equal to, the number of first dots 11 (remark: in

order to keep the drawings readable, only some of the first dots 11,

second dots 12 and microdots 13 are indicated by reference signs in

15   Figs. 1A - 1F). Figs. 1A and 1B illustrate a first embodiment of

the invention, wherein first FM screening is applied (see Fig. 1A)

and then AM (Fig. 1B). In Fig. 1C the second dots 12 grow further

by the addition of microdots. In Fig. 1D, which illustrates a

second embodiment of the invention, all the second dots 12 have

20   grown from the first dot size (of the first dots 11 in Fig. 1A) to a

second dot size. Shown in Fig. 1D is a second dot size of 3x3 = 9

microdots, while Figs. 1A - 1C show a first dot size of 2x2 = 4

microdots. The location of the dots is determined as follows.

First a randomized Bayer matrix is generated; this matrix is

25   subdivided into a plurality of parcels; the parcels themselves may

be subdivided again, in a number of steps as disclosed in

EP-642259-B1 cited already above, until the finally obtained parcels

have a parcel size equal to the second dot size, i.e. of 3x3

microdots. In fact, in Fig. 1A, the first dots 11 having a first

30   dot size of 2x2 microdots are generated in a 3x3 CristalRaster™

screen. With increasing density, these dots then gradually grow,

and all have a second dot size equal to the parcel size of 3x3

microdots in Fig. 1D. In Fig. 1D, the microdots that are not turned

on, i.e. that are not black, can be regarded as white "holes" 14.

35   These holes 14 have a size equal to the second dot size, i.e. 3x3

microdots, in Fig. 1D. With further increasing density, from
Fig. 1D to Fig. 1F, the size of the holes 14 is gradually decreased,
from a size equal to the second dot size of 3x3 microdots in Fig. 1D
to a size equal to the first dot size of 2x2 microdots in Fig. 1F,
by gradually turning on microdots in the holes, as shown in Fig. 1E.
In Fig. 1F, the remaining holes 15 have a size of 2x2 microdots;
moreover, some of the holes were already removed completely in
Fig. 1F to increase density still further.

        The invention is not limited to the embodiment discussed above.
In Figs. 1A - 1F, the dots grow from a size of 2x2 microdots to a
size of 3x3 microdots, but of course other dot sizes may be used,
such as 1x1, 2x3, 2x1, etc. Moreover, instead of generating the
location of the dots according to a randomized Bayer matrix, any
mask-based FM screening method that makes use of a threshold mask
array may be applied. Besides methods based on the Bayer matrix,
the so-called blue noise mask method disclosed in US patent no.
5,111,310, herein incorporated by reference in its entirety for
background information, is an example of a mask-based FM screening
method. The threshold mask array is then subdivided into a
plurality of parcels, as discussed above.

        Fig. 2 illustrates in detail a way of gradually increasing the
dot size, and decreasing the hole size. To simplify things, a
square of only 9x9 microdots 13 is shown; in reality, a threshold
mask array will usually comprise many more microdots, e.g. 512x512
microdots. In Fig. 2, each of the microdots 13 of the square of 9x9
microdots 13 has a number inside. These numbers inside the
microdots are not reference signs; they indicate the sequence
wherein the microdots are added, i.e. turned on, as explained below.
The square of 9x9 microdots is divided by lines 18 into four
adjacent dots having a dot size of 3x3 microdots. The microdots are
turned on according to the following sequence. First, the four
microdots with number 0 are turned on, and then the four microdots
with number 1, so that two dots 11, called first dots 11 in Fig. 1A,
are generated. These first dots 11 have a dot size of 2x2
microdots. Then, these first dots 11 grow: the microdot with number

2 is turned on, then the microdot with number 3, then number 4, etc.
After adding the microdot with number 11, both first dots 11 now
have a size of 3x3 dots, and two 3x3 holes remain, in the upper
right and the lower left quadrants of the 9x9 square. The size of
these holes is gradually decreased, by turning on the microdot with
number 12, then 13, and so on, until number 21. Now two holes 15
with size 2x2 microdots remain. By adding the four microdots with
number 22, and then the four microdots with number 23, all the
microdots are turned on, so that a density of 100 % is reached.

Preferably, a given number of first dots are generated, so that
a predetermined density is reached, before the dots start to grow.
This can be realized by the following algorithm, that is illustrated
by Fig. 3 showing values along a density axis D:

I)   for low densities, a number of first dots having a size
      of BeginSize x BeginSize microdots (e.g. 2x2 if
      BeginSize = 2) are generated, until Begin% of all dots
      are generated (i.e. of the remaining (100 % - Begin%)
      dots, no microdots are yet turned on). If these first
      dots are generated in a threshold mask array having a
      parcel size of EndSize x EndSize (e.g. 3x3), then a
      density of $B1 = (BeginSize^2/EndSize^2)*Begin\%$ is reached
      when all Begin% dots are turned on. This density B1 is
      indicated in Fig. 3 by co-ordinate 21 along density axis
      25. Thus, in interval (I) of the density axis 25, i.e.
      from 0 % to B1 %, FM screening is applied;

II)   then, in a second step, the first dots gradually grow
      from BeginSize x BeginSize microdots to EndSize x EndSize
      microdots. Preferably, one microdot is added to each
      first dot, then a second microdot is added to each first
      dot, and so on, as discussed above in connection with
      Fig. 2, until all first dots have a size of
      EndSize x EndSize microdots. When all first dots have
      this size, density is Begin%, indicated by co-ordinate 22
      along density axis 25. This second step, in which AM

screening is applied, corresponds to interval (II) along
density axis 25;

III) subsequently, additional dots are added that have a size
of EndSize x EndSize microdots (i.e. the second dot size,
as called in Figs. 1A - 1F; remark: in Figs. 1A - 1F, no
such additional dots were added). This is again FM
screening, corresponding to interval (III) in Fig. 3.
This step ends when End% of the dots are turned on. The
density is now End%, which is indicated by co-ordinate 23
along density axis 25;

IV) then, the hole size is decreased from EndSize x EndSize
to BeginSize x BeginSize microdots. Density increases to
$E1 = 100 - (100 - End\%) \times (BeginSize^2/EndSize^2)$, indicated
by co-ordinate 24 along density axis 25, when all holes
have a size of BeginSize x BeginSize microdots. In this
step of the algorithm, AM screening is applied; the
corresponding density interval is interval (IV);

V) in the final step, which is FM again and corresponds to
density interval (V), the holes are removed. Density
increases from E1 to 100 %.

In the algorithm as set out above, the dots are square. The
algorithm can however easily be generalized to rectangular dots, by
replacing the parameter BeginSize by two different parameters,
BeginSize1 and BeginSize2, and by replacing EndSize by EndSize1 and
EndSize2.

If End% = 100 - Begin%, the algorithm is symmetrical with
respect to dots and holes. An example is Begin% = 25 % and
End% = 75 %. For BeginSize = 2 and EndSize = 3, this results in
B1 = 11 % (meaning that dots start to grow at 11 % density) and
E1 = 89 %.

Fig. 4 illustrates how density varies for the embodiment
discussed already above in connection with Figs. 1A - 1F. In this
case, Begin% = End% = 50 %, so that there is no interval (III) in

Fig. 4. For BeginSize = 2 and EndSize = 3, dot growth starts at
B1 = 22 %, and E1 = 78 %.

An advantage of a method in accordance with the invention is
that clustering of dots in the midtones is more controllable, which
results in a higher perceived quality of the printed image in the
midtones. This is illustrated by the simplified example of Figs. 5
and 6. Fig. 5 shows "grown" dots 12 of an embodiment in accordance
with the invention. The density is 44 % (44 % = (16/36)*100 %; 16
of the 36 microdots are turned on in Fig. 5). The same density can
also be obtained, by a prior art method as shown in Fig. 6, by
turning on four dots of 2*2 microdots (so that also 16 of the 36
microdots are turned on). Since, especially when using a Bayer
matrix, the 2*2 dots are initially positioned far away from each
other, but not according to a regular pattern, it becomes difficult,
in the midtones, to add new dots, and the new dots often lead to
uncontrolled clustering, as illustrated in Fig. 6.

Another advantage of the invention is that, depending on the
design of the writing heads of some imagers, some severe banding is
avoided. E.g. when interlaced imaging is used, in known FM screens
that make use of a single dot size very often a disturbing pattern
is observed. Using a screen in accordance with the invention may
then solve this problem.

Yet another advantage of the invention is that a higher screen
stability is combined with good reproduction of fine details in the
highlights and shadows. In the midtones, larger dots are used (e.g.
3x3 instead of 2x2) which is more stable in the imagesetter (or
platesetter) and in the pressroom. The smaller dots in the
highlights, and the smaller holes in the shadows, result in better
reproduction of fine details.

The invention can advantageously be used for computer-to-plate
packaging applications.

The invention also includes a printing plate and a printing
plate precursor made by a method in accordance with the invention.
A printing plate precursor is an imaging material that can be used
as a printing plate after one or more treatment steps, that

generally include image-wise exposure and processing. Such a
printing plate precursor is exposed according to a screened
representation in accordance with the invention. A printing plate
precursor or a printing plate in accordance with the invention has
5   ink-accepting areas and non-ink-accepting areas that correspond to a
screened representation in accordance with the invention.

Those skilled in the art will appreciate that numerous
modifications and variations may be made to the embodiments
10   disclosed above without departing from the scope of the present
invention.

List of reference signs

11 : first dot

12 : second dot

5   13 : microdot

14 : hole

15 : hole

18 : line

21 : co-ordinate

10   22 : co-ordinate

23 : co-ordinate

24 : co-ordinate

25 : axis

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